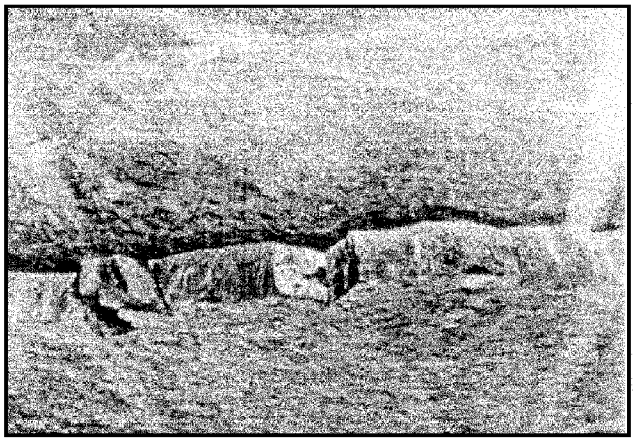
EVALUATING ROOF AND RIB HAZARDS IN THE UNDERGROUND STONE INDUSTRY

Anthony T. Iannacchione, Supervisory Civil Engineer
National Institute For Occupational Safety and Health
Pittsburgh Research Center

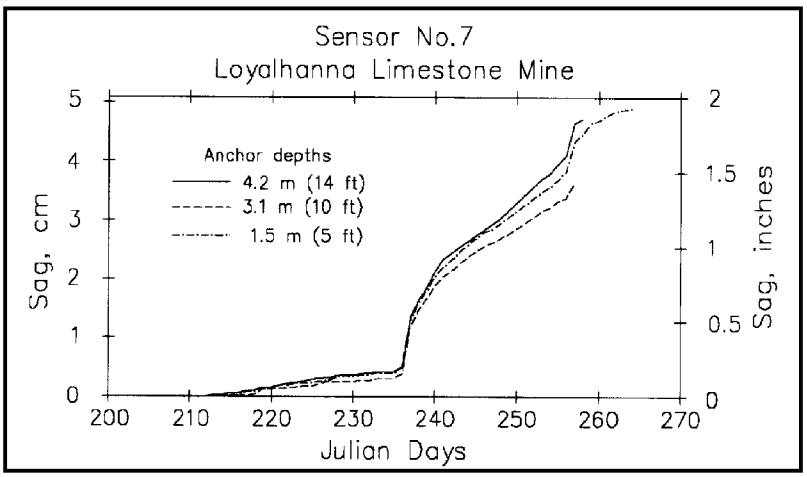
Unfortunately from 1991 through 1995, 44 miners were fatally injured in the stone industry with 12 occurring at underground mines from a total work force of less than 2,000 miners. Nine of these 12 miners were fatally injured in falls of roof or rib. A safer environment for the miners can be achieved by enhancing the industry's ability to evaluate the nature of the hazardous ground and by developing more efficient and effective ground control strategies. Roof and rib conditions in the underground stone industry were observed and assessed at 35 mines in Illinois, Indiana, Kentucky, Missouri, Pennsylvania, and West Virginia. Hazard assessment shows that ground failures occurring under moderate to substantial overburden (> 30 m or 100 ft) are caused by stress concentrations and geologic structures. Ground failures near the surface are typically caused by solution (water) processes. Selection of optimal mining horizon and mine layout has a profound influence on ground stability.



A limestone roof beam that has separated from the overlying rock along a smooth bedding plane and become unstable due to excessive sag and fracturing from vertical joints.

Of the 35 mines visited, 34 used the room-and-pillar mining method, which is most

efficient when mining results in a smooth, competent roof (back) and ribs (walls) free of loose rocks. Finding a mining horizon that has both a stable roof beam and a stable roof line, and determining an optimal mine layout are critical tasks in developing a safe and productive mine. Perhaps the first critical roof and rib safety consideration is to find a stable roof beam. The ideal roof beam is massive, strong, persistent, and weather resistant. Another important assessment factor is to evaluate potential stable roof lines. If several stable roof beams exist, the one that produces a persistent, smooth roof profile should be selected. If the stable roof line does not occur, then a smooth roof profile must be produced with drilling (altered drilling densities near the roof and rib line) and blasting (pre and post-splitting) techniques. After determining the optimal mining horizon, safe mine layouts need to be evaluated. Typically, mine layouts are controlled by haulage, ventilation, crushing, and storage requirements. More consideration should be given to designing the shapes, sizes, and orientations of mine structures, which minimize stress and geologic related hazards.



Automated three point roof sag extensometer showing the total anchor displacement measured from the roof (back) as a reference. In this example the majority of the movement was confined to the lower 1.5 m of roof and occurred in three distinct rates prior to the total roof failure.

With the exception of skin failure from the cracking of rock near the surface of the mine opening and block failure associated with large, well defined joint structures near the formations outcrop, most roof and ribs fail in response to sagging or buckling of beams. If roof beam sag can be detected and measured, then strategies can be developed to monitor and control these beams. Monitoring can consist of listening to noises made by rock as it fractures prior to failure, observing crack developments in roof and ribs, or detecting separations within the rock with instrumentation. Cracks and separations are typically detected with scratch tools, borescopes, and during drilling. In the last few years, mechanical roof monitoring devices installed in drill holes have become more popular. These monitors were originally single point extensometers used to measure the overall sag of the immediate roof beam. Magnitude of movement, rate of roof movement, and interval strain are measurements that can be used to determine operational responses, such as adding roof bolt support, removing loose roof rock, or dangering off an unstable area. Recently automated multipoint extensometers have been used to monitor hazardous roof and rib areas. These new instruments measure the specific behavior of unstable strata so as to provide an assessment of mining horizon and mine layout performance. Understanding how roof beams fail and observing and monitoring rock deformations can give critical information for making safety decisions, and potentially, provide a warning signal of impending hazardous conditions.